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VARIATIONS ON PIAGET'S PRE-NUMBER DEVELOPMENT

TESTS USED AS LEARNING EXPERIENCES

by

Hyrum E. Richards

A dissertation submitted in partial fulfillment  
of the requirements for the degree

of

DOCTOR OF PHILOSOPHY

in

Psychology

UTAH STATE UNIVERSITY  
Logan, Utah

1968

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Hyrum E. Richards

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## ABSTRACT

## Variations on Piaget's Pre-number Development

## Tests Used as Learning Experiences

by

Hyrum E. Richards, Doctor of Philosophy

Utah State University, 1968

Major Professor: Dr. David R. Stone

Department: Psychology

The effects of learning upon the rate of conservation attainment and its transference to other areas of performance were studied using 17 mentally retarded subjects.

Subjects found to be non-conservers on pretests were taught conservation and correspondence using a variety of tasks modeled from Piaget's experiments. They were also pretested on the WISC Information and Picture Arrangement Sub-tests and a number concept test. Following the learning experiences, the subjects were posttested using the same measures used for pretesting with the exception of the number test where an alternate form was used.

Significant correlations were found between the conservation pre-test scores and General Intelligence ( $r=.72$ ), Chronological Age ( $r=.66$ ), Mental Age ( $r=.91$ ), Information sub-test ( $r=.76$ ), Picture Arrangement sub-test ( $r=.83$ ), and number concept test scores ( $r=.64$ ).

There were significant posttest gains on conservation ( $F=79.98$ ,  $p<.01$ ), Information ( $F=14.56$ ,  $p<.01$ ), Picture Arrangement ( $F=6.62$ ,  $p<.05$ ), and number concept scores ( $F=6.99$ ,  $p<.05$ ), indicating tentatively that

conservation attainment can be accelerated by learning with a possible effect on related areas of performance.

Scores on an instrument designed to measure internalization of the concepts showed significant gains on posttest ( $F=15.97$ ,  $p<.01$ ). However, posttest scores on this measure did not correlate significantly with gains on other measures.

(75 pages)

## INTRODUCTION

### Need for Study

This study was concerned with the practicability of teaching the Piagetian concepts of conservation and one-one correspondence to educable mentally retarded children. These concepts were defined by Piaget (1965) as pre-number concepts and are maintained by him to be a necessary condition for an efficient and thorough assimilation and understanding of arithmetic notions.

Piaget (1965) demonstrated the developmental nature of these concepts in children. By using an interview technique coupled with the manipulation of concrete objects in the presence of the child, he was able to determine how children of various ages differed in their thinking concerning quantity and number. Piaget proposed three stages or levels of development in the pre-number concepts: (1) global--where the child is at the gross perceptual level and has no conservation, no reversibility, no one-one correspondence, and no seriation, (2) intuitive--cognitions are dominated by perceptions to a large degree, sometimes there is understanding of the concepts listed for stage 1, sometimes there is not, and (3) operational--where there is understanding of all the concepts listed under stage 1. This same developmental pattern was applied by Piaget to many other conceptual areas.

Research based on Piaget's work has largely been concerned with the replication of Piaget's experiments using larger groups of children. Results usually have shown rough agreement to Piaget's descriptions, although the stages of development have not been found to be as clearly

defined as his writings imply. A full discussion of this research will be presented later.

This study accepted the work done in previous research as having satisfactorily demonstrated the age-development relationship for the concepts of conservation and one-one correspondence, (Dodwell, 1961; Elkind, 1961a; Hodd, 1962) and addressed itself to the following questions: (1) could these concepts be taught to mentally retarded children, and (2) if they could be taught to these children, were there any advantages to the children?

It has been suggested that Piaget's tests for conservation and correspondence are in themselves learning devices (Dodwell, 1960). Churchill found some success in teaching these concepts to children (Dodwell, 1960). Smedslund (1961) was successful in teaching the concept of weight conservation to normal children, but questioned the permanence and practicality of the concepts when learned in this way. Piaget (1963, p. 359) himself inferred that environmental factors are important in the development of logical concepts.

\* Using Piaget's methods, researchers have found his theoretical developmental stages of intelligence (and also particular concepts) to be evident with mentally retarded children as well as the more normal (Woodward, 1959, 1962; Hood, 1962; Lovell, Healy and Rowland, 1962). It was found that evidence of the developmental stages occur later both in chronological and mental age with educable retarded children (Hood, 1962). These stages have been significantly correlated with arithmetic achievement, mental age, and WISC full scale scores as well as several subtest scores (Dodwell, 1961; Elkind, 1961a; Fryberg, 1966). Hood (1962) found that no mentally retarded children at stage 1 of

development in these concepts were successful in arithmetic, even though they were at the mental age at which normal children succeed.

Since mentally retarded children develop the pre-number concepts at a later mental age than the normal child, there is possibly a problem of synchronization of maturity level and experience for the retarded child who is growing up in an environment geared for the normal child. Perhaps there needs to be a more careful planning of early experiences. Further, since there is a relationship between the level of development in these concepts and school related factors such as arithmetic achievement and intelligence measures, the slower development of these concepts, found with the mentally retarded, may be an added hinderance to their success in school tasks.

There is a need then to clarify how effectively the pre-number concepts can be taught to mentally retarded subjects and whether or not there is any practical value to the children as a result of this learning.

This study used variations on Piaget's tests for pre-number concepts in teaching these same concepts to educable retardates, and evaluated the outcome in terms of (1) changes in levels of development in the concepts, (2) changes in the understanding of number, and (3) changes in certain WISC subtest scores.

#### Purpose of Study

The purposes of this study are: (1) to consider the effect of a certain type of learning experience upon the rate at which the Piagetian concepts of conservation and one-one correspondence develop,

and (2) to determine whether these concepts, if learned, generalized to affect measures of intelligence and/or understanding of number.

#### Organization of Study

- (1) Introduction
- (2) A review of literature related to the study
- (3) A description of the design, hypotheses, procedures, and statistical analysis used in the study
- (4) A presentation of findings
- (5) Discussion of findings
- (6) A final summary and conclusions



## REVIEW OF LITERATURE

The review of literature related to the present research was organized under the following main headings:

- (1) General theoretical background of Piagetian theory.
- (2) Research related in principle, but not specifically, to to the study at hand.
- (3) Research which leads directly into the present study.

### Theoretical Background

#### General intelligence theory

The present study focused on the change from non-conservation to conservation. This involves change in a child from pre-operational to concrete operational thought, as discussed by Piaget in his theory of cognitive development. It was thus deemed pertinent to present a brief discussion of Piaget's general theory of intellectual growth.

Piaget views intelligence as an adaptive process which is only a special case of the basic biological principle of adaptation (Piaget, 1963, p. 1-4). He postulates a definite sequence of developmental steps in intellectual development. In addition to these stage oriented aspects of Piaget's theory, Flavell (1963a, 1963b) pointed out three important functional processes which operate across all the stages of cognitive development proposed by Piaget. These three processes are assimilation, accommodation, and equilibrium. Piaget (1963, p. 6) discussed these three processes. Assimilation refers to the fitting of relevant environmental events into the existing cognitive structure.

Accommodation involves adjusting the existing structure to accommodate the new data which is being assimilated. Equilibrium exists when there is a balance between assimilation and accommodation. Flavell (1963b) referred to equilibrium as "the crowning structure" of each stage of development. When a gap between what is assimilated and what is accommodated exists, there is a state of disequilibrium. If disequilibrium is too great, learning is difficult.

An organized unit of interaction of the organism to the stimuli around him is called a schema (Tuddenham, 1966). It is these schema into which new data is absorbed by assimilation and which are modified, when necessary, by accommodation to adapt to the new information. In his discussion of Piaget's theory Berlyne (1957) pointed out that life begins with innate reflexes (or schema) which are modified and made effective by learning. New responses become part of the existing, but continually changing, repertoire of responses by the processes of assimilation and accommodation. According to Tuddenham (1966) motor actions constitute the basic schema from which the mental operations are built. He maintained that the most crucial assertion in Piaget's theory is that these mental operations are acquired in an orderly, predictable sequence. As discussed by Robinson and Robinson (1965) the development of intelligence, which is the attainment of more and more advanced mental operations, involves a systematic change in schema produced by assimilation and accommodation. Concurrent with this is a kind of hierarchal intercoordination of these schema.

The processes discussed thus far apply to intellectual functioning at all levels of development. However, Piaget is above all a developmentalist (Robinson and Robinson, 1965, p. 345). He postulates

for all individuals a definite sequence of developmental steps in the ontogeny of intelligence. Although Piaget is not consistent in every detail from publication to publication (Flavell, 1963a, p. 86), his descriptions of intellectual development, in general, present the same basic structure. The major epochs of the developmental sequence are called periods, some of which have sub-divisions called sub-periods. Periods and sub-periods can both contain smaller sub-divisions called stages, and stages are sometimes broken down into sub-stages (Flavell, 1963a, pp. 85-86; Robinson and Robinson, 1965, p. 345).

There were some discrepancies in the literature as to the organization or number of major periods proposed. Flavell (1963a), Robinson and Robinson (1965), and Hunt (1961) discuss three main periods with the second divided into two sub-periods. Berlyne (1957) discussed the same sequence under five main periods. \*Inhelder and Piaget (1958) and Piaget (1964) considered four main stages or periods in the development of intelligence.

The brief discussion of the developmental sequence which follows was based on the four stage model used by Piaget (1964), using the names involving periods and stages as presented by Flavell (1963a, pp. 85-87):

1. Period of Sensory Motor Intelligence: In his detailed description<sup>\*</sup> of this period, which lasts from birth until about 2 years of age, Piaget (1963) discussed 6 stages of development. He devoted a chapter to each stage providing both theoretical detail and observational data. Hunt (1961, pp. 116-1169), Flavell (1963a, pp. 87-155) both presented detailed descriptions of this period modeled upon the work of Piaget. Berlyne (1956), Robinson and Robinson (1965, pp. 345-348),

and Tuddenham (1966) are other examples of those who presented brief descriptions. The following discussion is a composite of information taken from the above references.

Stage 1: (about 0-1 month) The infant is born with a repertoire of innate reflexes or schema, for example the sucking and grasping reflexes. During this stage, he is completely ego-centered and spends his time repeating these responses, with no awareness of the objects in his environment.

Stage 2: (about 1-4 months) The infant begins to interact with his environment while changing and adding to his existing repertoire of reflex schemas. He begins to coordinate schema such as sucking with vision.

Stage 3: (about 4-8 months) The child begins to lose his egocentricity and becomes more aware of his environment and his effect upon it. He has not yet focused on objects in his environment, but does show recognition of familiar objects. He is very interested in the rubbing, swinging, and shaking of objects and is very much aware of sights and sounds.

Stage 4: (about 8-12 months) The child's orientation toward the outside world increases. He begins to show complex response patterns in interaction with his environment. The child also begins to anticipate future happenings, for example his mother leaving when she puts on her coat. He also tries to influence the future, or shows goal directed behavior, for example crying when his mother puts on her coat to prevent her leaving.

Stage 5: (about 12-18 months) Up until now the child has spent most of his time repeating behavior sequences which occurred originally

by accident. <sup>4</sup>During this stage, he actually devises and tests new response patterns or schema. He is now exhibiting what Piaget (1950, p. 104) calls true intelligence.

Stage 6: (about 18-24 months) Rudimentary symbolism appears, with the first indications of foresight and planning.

The changes discussed above occur as a result of sensory stimulations received by the child along with his motor activities in his environment. He began as a completely ego-centric being; he now conceives of himself as being separate from his surroundings. He can solve complex manipulatory problems, is beginning to piece together sound combinations, and has notions of space, time and causality.

Discussion of the three remaining periods, which follows, was based on information obtained from the following sources: Piaget (1964), Inhelder and Piaget (1958, pp. 245-255), Flavell (1963a, pp. 348-355), Berlyne (1957) and Tuddenham (1966).

## 2. Period of Pre-operational Thought: (about 2-7 years)

Stage 1: (about 2-4 years) This is sometimes referred to as the pre-conceptual period or phase. Up until now the child's intellectual functioning was concerned primarily with overt actions. With the development of symbolic processes he can begin to deal with the objects in his environment using internally organized conceptual systems which represent reality.

The child at this stage is subject to perceptual centering. When he considers static situations, he explains them in terms of their own configurations without consideration of changes involved from one situation to another. For example, the quantity of a given amount of liquid will be perceived as changing when poured into different shaped

containers. The child centers perceptually perhaps on the height of the liquid level, ignoring the diameter of the container.

Stage 2: (about 4-7 years) This is sometimes called the intuitive stage. The thinking of the child during this stage is still dominated by perception and he still centers and cannot consider all aspects. He is beginning now to have intuitive notions about quantity and transformations but as yet does not see clearly the reversibility of actions.

In the liquid quantity problem discussed for stage 1 a child at this stage might maintain two equal quantities to hold if container diameters are not too different. However, if liquid from one of two equal sized containers is transferred to a container of a much smaller diameter, the child's tendency to center perceptually is evoked and he will not maintain the constancy of the quantity. Static situations are still dominant over transformations.

3. Period of Concrete Operations: (about 7-12 years) During this period, operations (classifying, serial ordering, equalization, reversibility, etc.) become dominant over perceptions. In those spheres where a child has attained concrete thinking static situations are subordinate to transformations. Now any static state is conceived as the outcome of transformations.

The child develops clear concepts of classes, relations, closure, reversibility, associativity and identity. In other words, he attains clear concepts of quantity, number, and classes by which he internally organizes his world.

Concrete operational thought in one setting is not immediately generalized to all situations. For example, there is sometimes a time lag of several years between the organization of lengths and the

organization of weights under this type of thinking (Inhelder and Piaget, 1958, p. 249).

For the liquid quantity problem discussed under Period 2, a child at this level would immediately assert the constancy of a given quantity. The transformations of the liquid from glass to glass are easily reversible in his thoughts (operationally) and thus mass is conserved.

At this level, intellectual functioning deals with the real world<sup>x</sup> or concrete objects; it organizes directly and immediately given data but is still bound to the real or concrete. Possibilities are considered but are secondary to reality.

4. Period of Formal Operations: (about 12 years onward) At this level of development the person is no longer more or less confined to that which is real. Realities are now secondary to possibilities. He now has the capacity for purely abstract, logical thought. Hypothetical deductions are made independent of whether or not they may actually occur. The person can now formulate, test, reject or accept hypotheses all on the basis of his own logical operations without recourse to the concrete or real.

### Conservation

This study was concerned with 4 experiments dealing with conservation and one-one correspondence. These are:

- (1) Conservation of Continuous Quantities
- (2) Conservation of Dis-Continuous Quantities
- (3) Provoked Correspondence and Equivalence of Corresponding Sets
- (4) Spontaneous Correspondence, Cardinal Value of Sets

Following is a brief discussion of each of these types of conservation as presented by Piaget (1965, pp. 3-95).

1. Conservation of Continuous Quantities: This principle pertains to the permanence of mass regardless of changes in the shape of such substances as liquids, clay, and lengths of string. These are called continuous quantities because they are made up of units which cannot, in everyday life, be physically separated and counted.

2. Conservation of Dis-Continuous Quantities: This principle is concerned with the permanence of a given number of discrete objects. A certain number or amount of beans, coins, or such like remains the same regardless of spatial arrangement.

3. Provoked Correspondence and Equivalence of Sets: Two principles are involved here: (1) setting up a one-one correspondence between the elements of two sets which are qualitatively different but related by some external condition (for example, eggs and eggcups), and (2) conserving the equivalence of these two sets, once established, regardless of changes in spatial arrangement of either set.

4. Spontaneous Correspondence, Cardinal Value of Sets: Two principles are involved here also: (1) setting up a one-one correspondence between the elements of 2 sets of objects of the same kind for which there is no external relationship (for example, beads), and (2) conserving the equivalence of these two sets regardless of changes in spatial arrangement of either set.

\* Piaget (1965) considers these four principles in his discussion of the development of the concept of number in children. For each he specifies three general levels of development which he calls stages. Progress from stage 1 to stage 3 represents a major change from Pre-operational to Concrete Operational thought (Bruner, 1966). Hunt (1961, pp. 200-215) equates stage 1 to the pre-conceptual stage of the



Pre-operational period, stage 2 to the intuitive stage of the Pre-operational period, and stage 3 to the Concrete Operational period.

Inhelder and Piaget (1958, p. 247) and Piaget (1964, 1965) point out that development to the operational level in one concept or principle does not necessarily mean operational thinking in another. For example, conservation of mass precedes conservation of volume. But for each concept with which they have experimented, Piaget and his co-workers have found a similar 3 stage pattern of development, or 4 stage if they carry it to the Formal Operational level.

Following is a general description of these 3 stages of development as discussed by Piaget (1965, pp. 1-95).

Stage 1: This is called the global stage. Thinking here is similar to that described under Pre-operational period, stage 1. Quantitative judgements are distorted by perceptual centering. As applied to the 4 concepts discussed above, there would be no conservation, no one-one correspondence, and no lasting equivalence of sets.

Stage 2: This stage is referred to as the intuitive level. Thinking is pretty much the same as in stage 1, but the child is beginning to coordinate static states with transformations. There is a beginning of reversibility, conservation if shapes are not too different, and one-one correspondence usually without lasting equivalence of sets. Piaget calls this a transitional stage.

Stage 3: This is the operational level. Transformations now dominate static states. There is conservation, correspondence and lasting equivalence of sets regardless of the shape or arrangement of the substances or objects in question.

### Experiments Based on Piaget's Stage Theory

As has been discussed above, Piaget proposed a structure of intellectual development which follows a rather fixed sequence. However, the child does not suddenly jump from, for example, Pre-operational to Concrete Operational thought (Inhelder and Piaget, 1958, p. 249).

Much of Piaget's recent work (Flavell, 1963a, Hunt, 1961) has been concerned with transition from stage to stage of development. In so doing he has considered the evolvment of such things as children's conceptions of space, number, justice, measurement and socialization. In considering development up to the Concrete Operational level, Piaget has found answers from children classifiable into 3 groups which distinguish stages 1, 2, and 3 discussed above (Piaget, 1965; Hunt, 1961). In some cases (Piaget and Inhelder, 1958) he carried the experiments to the Formal Operational level and thus defined four main stages.

Piaget obtained much of his information (Piaget, 1950, 1959, 1960, 1963) by watching and listening to children and questioning them. In recent years (Inhelder & Piaget, 1958; Piaget, 1964, 1965) he has studied transitional aspects of intellectual development by manipulating physical objects in the presence of the child, coupled with a semi-clinical interview technique to get at the child's thinking.

Some studies have tested various groups of children, in quite a general way, to determine if responses obtained were comparable to those reported by Piaget. Others have rigorously repeated specific Piagetian experiments to see if his results were replicable with different samples. A sample of the studies done along these lines will be discussed in order to illustrate the kinds of descriptions used by Piaget.

Dennis (1940) applied Piaget's semi-clinical techniques in studying Zuni and Navajo children and obtained answers similar to those reported by Piaget. He concluded that the thought tendencies described by Piaget were universal and not learned from particular cultural experiences. In analyzing children's statements about life and death, Steiner (1965) concluded that their thinking in this area was consistent with Piaget's theory of cognitive development. Similar conclusions were reached by Goldman (1965) using religious pictures as stimuli. He found Piaget's views on the development of operational thinking to be demonstrated in the responses made by children to religious pictures. Robinson (1964) studied the developmental nature of the size-weight illusion in children. His findings disagree with specific Piagetian views concerning this phenomenon, but he maintained that his results were consistent with Piaget's general theory.

Others have turned their attention to more elaborate descriptions of periods or stages of development. Some have investigated specific periods in detail, and others have been more interested in transition from period to period or stage to stage.

Woodward (1959) observed the behavior of a large number of severely retarded subjects. She traced in great detail the development of what Piaget has called Sensory Motor Intelligence. The responses of her subjects closely agreed with those reported by Piaget for normal children. She concluded that development at this level followed the same sequence for mentally retarded as for normal children. The Sensory Motor period was also studied by De'carie (1965). She compared<sup>\*</sup> intellectual development and emotional development. She was able to observe the developmental sequence proposed by Piaget. With her subjects

Piagetian levels of development were strongly related to mental age, and these plus environment were strongly related to emotional development.

Concerned with transition from period to period, Lodwick (Peel, 1959) confirmed roughly the Pre-operational, Concrete Operational, and Formal Operational levels of thought. His subjects showed more diffuseness among the three levels than reported by Piaget. There was a higher correlation of level of development with mental age than with chronological age. Lovell (1961) used a variety of Piagetian experiments covering such tasks as equality of angles, law of floating bodies and oscillations of a pendulum. With a large number of children he demonstrated the general stages for the growth of logical thought as proposed by Inhelder and Piaget (1958).

Others have turned their attention to test for rather abrupt changes within the sequential development proposed by Piaget. L'Abate (1962) tested Piaget's proposition of a striking change from a global to an analytical view of reality. Using a multiple choice picture test, he found an age related trend toward more and more analytical picture choices. He concluded that his results generally supported Piaget's theory. Analyzing word definitions given by children, Wolman and Barker (1965) could not demonstrate a discrete swing from "use" oriented definitions to "essential characteristic" oriented definitions. As a result they questioned, at least in this area, Piaget's proposition of disequilibrium and change in mode of thought.

Using frequency of figure-ground reversals with children of various ages, Elkind and Scott (1962) found support for Piaget's prediction that reversals would increase with age. Piaget predicted that

since reversals of figure and ground involved logical mental operations which increase with age, reversals would therefore increase with age. Some Gestaltians had predicted a decrease in reversals with age due to neurological satiation.

### Studies on Specific Concepts

Piaget and Inhelder (1956) proposed a 3 stage development in the child's conception of space: (1) Topological space wherein there is no coordination of objects in space; no conservation of distances, angles, or size of objects. This is a rather global or vague conception of space; (2) Projective space wherein there is an intuitive organization of space and the objects in it. This organization is maintained by a mental image of space; (3) Euclidean space which is a space organized according to the coordinate axes at the operational or logical level of thought.

Several replications of the work of Piaget and Inhelder on the development of the spatial concept have been done. Fern and Page (Peel, 1959) analyzed the haptic perceptions and drawings of children. They found their subjects did progress according to age in the development of spatial concepts. They showed the stages of spatial conception proposed by Piaget and Inhelder to be well-demonstrated by their study sample, with some reservations concerning age limits. Repeating Piaget's and Inhelder's experiments on space conception under more controlled conditions, Lovell (1959) found rough agreement with the original work. He was critical that the age variation allowed by Piaget and Inhelder was too limited, and was somewhat skeptical of the topological to Euclidean space notion. Dodwell (1963) also roughly

corroborated the three stages of spatial conception, as did Woodward (1962) and LeCrosse (1967).

Similar to his discussion of the conception of space in children, Piaget also postulated three levels or stages in the child's conception of justice (Durkin, 1959b). These are: (1) justice vested in the authority person; (2) justice in reciprocity and, (3) justice in reciprocity plus equity. Grinder (1964) roughly confirmed Piaget's viewpoint so far as verbal expressions of justice were concerned. He found, however, that these cognitive ideas of justice were not practiced by children when they had the opportunity to cheat in a game. The three stages generally held for both normal and retarded subjects studied by Bobcoff (1960). He also found a significant correlation between the Piagetian stages of justice and level of ego development as estimated from TAT protocols. Durkin (1959a, 1959b, 1960) demonstrated the first two stages with his samples, but observed that children of the stage 3 age reverted back to authority centered belief of stage 1. This same pattern was roughly approximated by Oudin (1966).

Other studies have been done which question the three stage sequence of development with various concepts. Replicating the experiment of Piaget, Inhelder and Szemensi (1960) on the conception of geometry, Lovell, Healy and Roland (1962) found agreement with their proposed three stages of development. They did find cause for disagreement over the age factor. Elkind (1961a) demonstrated the three levels of gross, intensive, and extensive quantification proposed by Piaget. He also agreed with Piaget on the sequential nature of conservation from mass to weight to volume (Elkind, 1961b). Elkind (1961c) had similar results when replicating Piaget's work on additive composition

of classes, and also with the three stages of development of the concept of left and right (Elkind, 1961d). Belbin and Franklin (1962) tested Piaget's views on the three stage pattern in the development of the concept of measurement. They found length and area measurement developing concurrent with some concepts of conservation, followed by volume measurement. Their only disagreement with Piaget was that with their sample length measurement preceded area measurement. Piaget found these developing simultaneously.

### Studies on Conservation

Since the present study is concerned primarily with experiments on conservation, this particular concept will be reviewed in some detail.

+Piaget (1965, p. 3) asserts, "Every notion, whether it be scientific or a matter of common sense, presupposes a set of principles of conservation, either explicit or implicit." Along the same vein, Bruner (1966, p. 183) says, "Indeed much of common sense and all of science would be impossible without conservation."

Research dealing specifically with conservation will be considered under the following five sub-topics:

- (1) Examples of experiments on conservation and correspondence
- (2) Experimental testing of Piaget's views on conservation
- (3) Research testing the applicability of these same ideas to mentally retarded children
- (4) Considerations of inter-relations between conservation, intelligence measures, and arithmetic achievement
- (5) Research concerned with inter-relations between conservation and learning.

### Examples of Experiments

Piaget (1965) described experiments which he used for conservation and correspondence. One example will be presented for each of the four principles with which this study was concerned.

1. Conservation of Continuous Quantities: The child is given two containers, A1 and A2, of equal dimensions. A1 and A2 contain equal quantities of liquid. When the child has ascertained that the amount of liquid in A1 is equal to that in A2, the liquid from A2 is poured into a container B which has a smaller diameter than A2. The child is then questioned about the equality or non-equality of the amounts of liquid in A1 and B. Children at stage 1 will not conserve, but will center on the height of the liquid and call that in B more than in A. Stage 2 children might conserve if levels in A1 and B are not too different, but when they are quite different will revert to non-conservation. Children at stage 3 will consistently maintain the equality of the 2 amounts of liquid. They have internalized the principle of conservation.

2. Conservation of Discontinuous Quantities: The experiment discussed above can be repeated using beads. The quantities can be evaluated globally, or with the child counting the elements. In addition to testing for conservation, these experiments, when counting is used, also get at one-one correspondence.

3. Provoked Correspondence and Equivalence of Corresponding Sets: The experimenter places a certain number of milk bottles on the table and asks the child to select an equal number of glasses from a group of glasses. This tests for one-one correspondence provoked by the relationship between milk bottles and glasses. When two corresponding



or equal sets have been established, the glasses are bunched together and the bottles remain spread apart. The child is then questioned as to the equality or non-equality of the two sets. Stage 1 children do not have one-one correspondence or conservation; stage 2 have one-one correspondence but do not conserve; and stage 3 have both correspondence and conservation (or equivalence of sets).

4. Spontaneous Correspondence, Cardinal Value of Sets: Experiments here are similar to those for provoked correspondence except 2 sets of the same type of objects are used. For example, a certain number of beads are arranged perhaps in a circle in front of the child. He is asked to take the same number of beads from an available supply. When he has established the equality of the two sets, one set is compressed into a smaller area on the table. The child is then questioned as to the equality or inequality of the two sets. Stage 1 children have neither one-one correspondence or conservation. They roughly duplicate the arrangement of the first set of beads. Stage 2 children show some correspondence but are still tied somewhat to the arrangement of the beads. They do not conserve. \*Stage 3 children have one-one correspondence and conserve through use of counting numbers which Piaget calls the cardinal value of sets.

\* For variations on each of the experiments described above, see Piaget (1965, pp. 1-95).

#### Testing the Conservation Concept

Several replication studies have been done testing Piaget's findings on conservation. Most experimenters used larger samples under more rigidly controlled experimental settings. Lovell and Ogilvie

(1960), using experiments similar to those described above, reported strong support for Piaget's three levels of conservation development. However, they stated that the stages were not so clearly defined as implied by Piaget's writings. The reason most frequently given by children in this study as an explanation of conservation was reversibility. Conducting a similar experiment with Canadian children, Dodwell (1960) concluded that Piaget's descriptions of the developmental nature of conservation could be experimentally substantiated. He also found more confusion among stages than reported by Piaget. In his sample children were at different levels of conservation for different conservation tests. In related experiments Dodwell (1961, 1962) arrived at similar conclusions concerning conservation. Hood (1962) and Feigenbaum (1961, 1963) also had similar findings. Apparently conservation is not a simple, unified principle, but varies with context and problem. This, however, is not in disagreement with Piaget's own work (Inhelder and Piaget, 1958, p. 249; Hunt, 1961, p. 226; Piaget, 1964, 1965).

Estes (1956) performed several of Piaget's experiments with a large group of American children. Among other things, he reported children did not center on the length of rows of poker chips of different numbers and thus fail to conserve. He also did not get Piaget's results with marbles in different shaped jars. He concluded that there was no support for Piaget's views concerning the development of number and logic. In a follow-up study on the work of Estes, Wohlwill (1960) obtained findings contradicting those of Estes and supporting Piaget's. In view of his and other work in the area, Wohlwill concluded Estes' findings were due to a poor sample and inadequate methodology.

Mehler and Bever (1967) conducted an experiment with children 2 years of age and older. In their sample, children under 4 years of age had a form of conservation which was lost as they approached 4 years of age and regained at about 6 years of age. This age group had not previously been considered in experiments with conservation, and thus an important issue is raised concerning the developmental sequence.

Other recent work concerning conservation has been conducted by Bruner (1966) and his associates, Sonstroem (1966) and Greenfield (1966). Their work seems to reflect the general consensus that there is a developmental aspect involved in conservation attainment. At the same time, there is a need to clarify the details involved in the process of attaining conservation, especially with varied tasks. There is a need also (Bruner, 1966) to try other models of explanation in addition to Piaget's logical-mathematical model.

#### Conservation and the Mentally Retarded

There have been several studies which deal with concepts other than conservation as applied to the mentally retarded, but to date there has been limited research related specifically to conservation involving mentally retarded subjects.

Woodward (1959) observed carefully a large number of severely mentally retarded children and recorded their behaviors. She was able to group each observed behavior so that it could be categorized under one or another of the 6 stages of the Sensory Motor Period. She was thus able to demonstrate a sequence of Sensory Motor Development for severe retardates very similar to that reported by Piaget for normal children. Applying Piaget's three levels of spatial conception

to less severely retarded subjects, Woodward (1962) was again able to replicate Piaget's and Inhelder's pattern of spatial development discussed earlier. Wolensky (1965) presented retarded children with Piaget's tests of estimating angle size, intersecting forms, and vertical-horizontal illusions to study spatial conception. He noticed that retardates go through the same stage of spatial conception as normal children. They proceed more slowly, however, and terminate at a lower level of development.

Lovell, Healey and Roland (1962) used 12 experiments on geometric conception (Piaget, Inhelder and Szemenshy, 1960) with a sample of normal children and a sample of mentally retarded children. They were able to group children from both samples according to the Piagetian 3 stage model, but noted that the number of children found at various stages was different from that expected on a basis of the study by Piaget et al. With their sample, mentally retarded subjects of 14 or 15 years of age were at levels in geometric conception found among normal children 7 or 8 years old.

Hood (1962) administered tests for conservation, similar to those discussed earlier, to mentally retarded and normal subjects. His findings revealed similar developmental patterns for both groups. However, mentally retarded subjects attained conservation not only at a later chronological age than normals, but also at a later mental age. Normal children from 6 to 8 years in mental age had the most active change from Pre-operational to Concrete Operational thinking, while the most active change period for mentally retarded was beyond the mental age of  $8\frac{1}{2}$  years.

Conservation as Related to Intelligence  
and Arithmetic Measure

Some research has correlated Piagetian levels of conservation with standardized intelligence measures such as the Stanford Binet and WISC. Testing the interaction between Stanford-Binet intelligence scores and conservation test scores, Feigerbaum (1963) obtained interactions in 3 out of 4 tests for conservation. He concluded there is an interaction of general intelligence and age in the attainment of conservation. Elkind (1961a) found significant correlations between Piagetian levels of quantitative thinking and various WISC scores. The Information Arithmetic, Picture Arrangement, Object Assembly, and Coding sub-test scores and the Verbal and Full Scale scores correlated with scores on Piagetian type tests beyond the .01 level of significance.

Not so directly, Hood (1962) reported a higher relation between level of conservation and Terman-Merrill mental age, than between level of conservation and chronological age. Along this same line, Lovell (1962) and Woodward (1959, 1962) have noted the slower progress of mentally retarded in the developmental sequences proposed by Piaget.

→ Since Piaget (1965) presented conservation as one of the developmental aspects in a child's conception of number, it was natural that the relationship of conservation to number or arithmetic achievement was investigated. Dodwell (1960, 1961) studied this relationship. He found that counting per se was no guarantee that children understood number. With his samples conservation did not prove to be a good predictor of arithmetic achievement beyond grade one. However, when he correlated conservation level with scores on arithmetic readiness test predictions of success in grade one, he did find a

significant correlation ( $r=59$ ). From this he concluded that the Piagetian conservation tests were fair measures of arithmetic readiness in kindergarten. In a more objective approach to number achievement, Averholt (1965) reported a relationship between conservation and understanding of arithmetic with both of these inter-related with intelligence. Hood (1962) set up measures for 5 stages of number development. He then made comparisons of those stages to stages in conservation attainment. No child at stage 1 of conservation was at stage 5 in number, and no child at stage 3 in conservation was at stage 1 in number. Mentally retarded non-conservers were very weak in arithmetic and conservers were making favorable progress. Hood found no instance of a mentally retarded child who had failed the conservation tests who was performing successfully in arithmetic.

### Conservation and Learning

Although Piaget emphasized developmental prerequisites in his theory of intellectual growth, he did, at times, point to the importance of environmental interactions in conjunction with maturation (Piaget, 1963, p. 359). Studies dealing with this problem fell into 3 general categories: (1) deliberate teaching of concepts such as conservation, (2) influence of formal schooling on the attainment of conservation, and (3) theoretical consideration of the implications of Piaget's theory in the field of education. These three categories will be discussed in the order listed.

After presenting some Piagetian tests for conservation to children, Lovell and Ogilvie (1960) observed that the tests themselves were learning experiences. Smedslund (1961) taught non-conserving children

conservation of weight using illustrations with clay and balances. He found that children who learned conservation in this manner were more susceptible to extinction of conservation than children who attained it normally. He concluded support for the importance of maturation over learning. Bruner (1966) noted an increase in conservation for 5 year olds but not for 4 year olds as an outcome of testing experiences on conservation. Sonstroem (1966) reported that children who manipulate clay in conjunction with labeling (verbalizations about length and width relations) had a high ratio of success in learning the conservation of solids. Sigel (Stendler, 1965) had 80% success teaching non-conserving, bright, pre-school children to conserve. Churchill (Dodwell, 1960) also reported some success teaching conservation to children.

There is some controversy as to the influence of formal schooling on the attainment of conservation. Greenfield (1966), on the one hand, found Senegalese children attending school to be very similar to American children in their developmental pattern of conservation, while those not attending school conserved much later or not at all. On the other hand, Mermelstein and Shulman (1967) reported no relationship between formal schooling and conservation attainment.

Other writers have considered Piaget's theory to hold important implications for the field of education. Wolensky (1962) and Gilmary (1964) both stress the usefulness of the Piagetian techniques in discovering the child's level of thinking. They further recommend concrete manipulations, such as those used by Piaget in his work, to help the child progress logically. Stendler (1965) suggests that development requires a mixture of maturation and logically arranged

experience. He recommends direct teaching of logical concepts, such as conservation, as a method for improving school performance. In an experiment aimed at improving school performance, Levi (1966) attempted to move mentally retarded children from the Pre-operational to the Concrete Operational level of thinking. He started with a series of picture exercises and progressed to verbal exercises. He reported improved school performances for all subjects in his study.

### Summary and Comments

Although conservation in one task does not imply conservation in another, in a general way Piaget's model for intellectual development has been verified by research. There has been disagreement on the value and possibility of any kind of age norms for cognitive development, although the sequence of stages within given tasks is widely accepted.

Piaget's view is that operational thought occurs at different times for different tasks. It is not a mental process which is developed as such (Inhelder and Piaget, 1958, p. 249; Piaget, 1964, 1965; Hunt, 1961, p. 226). This view has been misinterpreted by some writers (L'Abate, 1962; Wolman and Barber, 1965) who have predicted very striking changes from one mode of thought to another on a basis of Piaget's writings. As a result, criticism on this aspect of Piaget's theory has arisen when measured changes were more gradual. However, since Piaget does not propose such striking changes, this particular criticism seems invalid.

There have been other specific areas of disagreement. Ausubel (1965, 1966) maintained that there is contradiction in the continuity



Piaget proposed between early motor stages of development and later verbal stages. He was especially skeptical of the view that reflexive behavior evolves into non-reflexive behavior, and would prefer to keep the two separate. Whereas Piaget sees one level of functioning being modified to a higher level of functioning in a kind of stage-transformation theory, Ausubel seems to view different levels of functioning each developing concurrently with each other. In Piaget's view, logical thought would come with maturation. In Ausubel's view, the child would start out with mechanisms for logical thought, separate from his reflexes, and perfect these with maturation.

Wohlwill (1963), though not critical of Piaget's theory, saw a strong need for clarification of the rather fixed sequence of concept development. In other words, there is yet much to be done to fully establish the rather invariant, predetermined, developmental sequence proposed by Piaget. Some evidence for this need is found in the work of such writers as Gunder (1964), Durkin (1959a, 1959b, 1960) and Cudin (1966), all of whom found some disagreement with the fixed sequence proposed by Piaget for the child's development of a concept of justice. The question raised is not so much as to the fixed sequence but to the identification of it.

Some writers believed that Piaget's interest in mathematics and logic had biased his theoretical model of intellectual development. His basic explanation for the attainment of conservation, for example, is questioned by Bruner (1966). \*Piaget views the attainment of conservation as an outcome of logical operations: first, reversibility or the operation of mentally restoring materials to their original state; second, at a higher level, compensation where, for example, the

child mentally multiplies increased height by decreased width. Bruner believes conservation results from a more basic concept of identity: first, learning that one given quantity of a substance remains the same even when its shape is changed, then learning to apply identity across complicated transformations involving more than one quantity of a substance. †Elkind (1967) argues that disagreements over conservation have arisen because of not differentiating two kinds of conservation which are implied but not clearly defined by Piaget. These are identity conservation wherein only one quantity of a substance is involved, and equivalence conservation which includes identity conservation but goes further in allowing comparison of two quantities.

The above arguments hold to the highly theoretical aspects of Piaget's theory which are, of course, important and appear to be testable areas of research (Bruner, 1966). At the more applied level, as found in the preceding review of literature, there are many areas in Piaget's theory with which general agreement has been experimentally demonstrated. What this provides in the realm of educating children is rather direct measurements as to the child's level of intellectual functioning. This is true not only in a general sense, but perhaps more importantly, with specific concepts such as conservation.

Of course, in retrospect it seems obvious that a child will progress from less understanding to more. The description of this process as related to specific concepts does add to our knowledge of how children think. However, the investigation of general principles of change which characterize increasingly adequate performance still needs attention. More specifically, can the descriptions of conservation

attainment be utilized in bettering the child's performance in the school setting for example?

Along this line of reasoning, some unresolved issues concerning conservation as applied to problems of the mentally retarded are:

- (1) Is the late development of conservation a critical factor in the learning performance of the mentally retarded?
- (2) Can this inadequacy (lack of conservation) be decreased by a direct teaching of conservation?
- (3) Does the principle of conservation, when learned in this manner, generalize to other areas of performance?

Robinson and Robinson (1965, pp. 34-35) defined mental retardation as a level of intellectual functioning which inhibits the adaptive processes of maturation, learning, and social adjustment. Societies are geared to the normal child. Experiences then have a higher probability of being synchronized with the maturational level of the more normal child. This possibly partially explains the occurrence of conservation at a later mental age as well as chronological age in the mentally retarded. Further, as the mentally retarded child progresses in school, his curriculum, based somewhat on mental age, possibly assumes conservation before he has achieved it. The problem is thus compounded.

Research reviewed earlier, which has applied Piagetian techniques to the mentally retarded, has demonstrated the following:

- (1) The developmental sequence for retarded is similar to that of normal children.
- (2) The progress of mentally retarded is slower as measured by both chronological and mental age.

- (3) There is a relationship between Piagetian levels of development and standard IQ measures.
- (4) There seems to be a relationship, especially with mentally retarded, between level of conservation and arithmetic achievement.

Learning is involved in the growth of intellectual functioning (Hebb, 1949). Some of the studies reviewed here have shown that learning can be a factor in the attainment of conservation. Since lack of conservation seems to be a determinable inadequacy of mentally retarded children, there may be some value in teaching it to them directly. In so doing, it would seem important to test for effects on the adequacy of performance in areas other than conservation.

## METHODS AND MATERIALS

### Statement of Problem

Providing an effective educational setting for the mentally retarded child involves structuring a suitable environment for a child whose rate of development is divergent from the norm. The major problem of retarded children is in trying to adapt to an environment structured for a rate of development different from their own.

It is considered of basic importance that a child, or any organism,<sup>\*</sup> be exposed to pertinent experiences when he is maturationally ready for them. Research has indicated that poor synchronization of maturation and experience can have an inhibitory effect on learning ability. (Hebb, 1949; Dennis and Najarian, 1957; Dennis, 1960; Spitz, 1945, 1947).

Mentally retarded children have been found slow in attaining conservation (Hood, 1962). Perhaps the experiences which help the normal child develop conservation are thrust upon the mentally retarded before he is maturationally ready for them. His problem is compounded when he begins school and is faced with learning tasks which assume conservation, as nearly all that is taught in school does (Bruner, 1966; Piaget, 1965; Stendler, 1965).

Lack of conservation is possibly an important deficit to be uncovered, and also one which would not likely be detected by standard intelligence measures. If detected, it follows that it would be important to deal with this deficit in an effort to help the child overcome it or live with it.

It has been suggested (Stendler, 1965; Levi, 1966) that providing experiences directly aimed at teaching basic concepts such as conservation may be an effective approach in dealing with learning problems. The basic problem of this study was to investigate this possibility.

### Design

A single group design was used. Each subject was administered the following pretests and posttests:

- (1) Piaget Type Tests for Conservation (Appendix A)
- (2) Picture Arrangement and Information Subtests from the  
Weschler Intelligence Scale for Children
- (3) Number Concept Test (Appendix D)
- (4) Conservation Test with Motivational Involvement (Appendix B)

Using conservation pretest scores as a criterion, the subjects were divided into four treatment groups of from 3 to 5 children per group. Each group was exposed to five 50 minute periods of instruction. Within one or two days of the final instruction period, the posttests were administered.

### Hypotheses

Based on findings from previous research discussed in the review of literature, the following seven hypotheses were formulated:

- (1) There will be a positive correlation between scores on conservation pretests and intelligence test scores.
- (2) There will be a positive correlation between scores on conservation pretests and the WISC Information subtest scores.

- (3) There will be a positive correlation between scores on conservation pretests and the WISC Picture Arrangement subtest scores.
- (4) There will be a positive correlation between scores on conservation pretests and the chronological ages of the subjects.
- (5) There will be a positive correlation between scores on conservation pretests and the mental ages of the subjects.
- (6) There will be a significant correlation between scores on conservation pretests and the number concept pretest scores.
- (7) The scores on the conservation pretest will correlate significantly higher with the subjects' mental ages than with the subjects' chronological ages.

To get at the major purposes of this study, the following four hypotheses were tested:

- (8) For the conservation tests, the posttest scores will be significantly higher than the pretest scores.
- (9) For the Information (WISC) subtest, the posttest scores will be significantly higher than the pretest scores.
- (10) For the Picture Arrangement (WISC) subtest, the posttest scores will be significantly higher than the pretest scores.
- (11) For the number concept test, the posttest scores will be significantly higher than the pretest scores.

The Conservation Test with Motivational Involvement was used to test whether a child actually had learned conservation or whether he had learned only to verbalize correct answers to the tasks presented. On this basis the following four hypotheses were tested:

- (12) For Conservation Test with Motivational Involvement, the posttest scores will be significantly higher than the pretest scores.
- (13) Posttest scores on the conservation Test with Emotional Involvement will correlate positively with gains on the Information subtest.
- (14) Same as 12 for Picture Arrangement subtest.
- (15) Same as 12 for number concept test.

### Measures and Materials

1. Piaget Type Tests for Conservation: Tests here were modeled from those presented by Piaget (1965, p. 1-95) and discussed previously in the review of literature. A variety of materials such as water, various shaped containers, vases and flowers, milk bottles and glasses, and beans were used. Subjects were scored 1 point for each correct conclusion. A complete description of this measure is presented in Appendix A.

2. WISC subtests of Information and Picture Arrangement from a standard WISC kit were used. These subtests were selected because Elkind (1961a) found the highest correlation between these two and Piagetian measures.

3. Number Concept Test: Prepared by the writer and presented in full in Appendix B (Two Forms).

4. Conservation Test with Motivational Involvement: Similar to regular Piagetian conservation tests but used candy, fruit juice and money which the children were allowed to keep. Presented in full in Appendix C.



5. Variations on Piaget's conservation tests, using tasks differing from those used in the conservation pretests and posttests, were used as instructional materials. Presented in Appendix X.<sup>c</sup>

6. Various treats such as candy, gum, balloons, etc., were used as reinforcers in the learning sessions.

7. Either Stanford-Binet or Weschler Intelligence Scale I.Q. scores were available for each subject.

### Procedures

#### Subjects

The subjects were 17 educable retarded children involved in a special education program in a consolidated elementary school of about 600 students. They ranged in age from 7 years 9 months to 12 years 7 months. Their mental ages varied from 3-11 to 9-0, and I.Q.'s varied from 44 to 77.

The school is located in a farming community of about 3,000 population, and the students live either in this community or in smaller, surrounding communities. The subjects then were from a rural background, and their parents were largely either farmers or laborers.

#### Testing

Pretests and posttests were administered to each subject on an individual basis by the writer. Rooms were provided adjacent to the classrooms of the subjects for both testing and instruction which took place during school hours.

### Instruction

The subjects were divided into four groups on the basis of conservation pretest scores. The five highest scorers, the next five, and the next four, and finally the three lowest scorers made up the instructional groups.

Each group was involved in five 50 minute instruction periods:

Period 1: Conservation of Continuous Quantities.

Period 2: Review, and Conservation of Discontinuous Quantities.

Period 3: Review, and Provoked Correspondence and Equivalence of Sets.

Period 4: Review, and Spontaneous Correspondence, Cardinal Value of Sets.

Period 5: Review of all material covered in periods 1-4 (Teaching materials described in Appendix <sup>C</sup>~~D~~).

Concrete materials with which the above mentioned principles could be demonstrated were manipulated in the presence of the children. They were given careful explanations, and then questioned and re-questioned, as the materials were manipulated, until each subject in the group gave conserving answers.

To hold the attention of the children and provide motivation, a reward of 1 penny was given for each correct answer during the learning sessions. At the end of each session, the child could spend his pennies on candies, gum, balloons, etc., or keep them. This technique proved effective in holding the child's attention and in maintaining his interest in succeeding sessions.

During reviews, which were part of periods 2, 3, and 4, and all of period 5, the subjects were challenged when they made correct judgments.

If they changed their minds under pressure, they did not receive a penny. By the fifth learning session, most subjects had established resistance to being challenged and would maintain conservation under pressure.

In the two days that followed the instruction periods, posttests were administered. Pretesting, instruction, and posttesting covered a time lapse of four weeks.

### Statistical Analysis

To test hypotheses 1-6, product-moment correlations were obtained along with t-tests for significance (Ferguson, 1966, p. 186-187).

To test hypothesis 7, product-moment correlations were obtained along with the test for significance of difference between two correlation coefficients for correlated samples (Ferguson, 1966, p. 188-189).

Analysis of variance for the small, single group (Garrett, 1960, p. 291-292) was used to test for significance of the mean differences involved in hypotheses 8 through 12.

To test hypotheses 13-15, product-moment correlations were also obtained between final scores on the Conservation Test with Motivational Involvement and gains on Information, Picture Arrangements, and Number Concept Test.

## RESULTS

Tables summarizing the analysis of the data are presented, followed by a discussion of these analyses as they pertain to the hypotheses.

Table 1. Product-moment correlations of Piaget Type Conservation Test pretest scores with six other pretest scores

	I.Q.	Chrono- logical Age	Mental Age	WISC Infor- mation	WISC Pict. Arr.	Number
Piaget Type Conservation Test (df=16)	.721	.660	.915	.767	.834	.640

All of the above correlations are beyond the .01 level of significance.

On the basis of findings reported in previous research relationships of level of conservation attainment with intelligence, chronological age, mental age, WISC subtest scores, and number test scores were hypothesized. Product-moment correlations were obtained to test hypotheses 1-6. These are reported in Table 1.

Hypotheses 1-6 were supported. Conservation scores correlated with I.Q. level ( $r=.72$ ), chronological age ( $r=.66$ ), mental age ( $r=.91$ ), Information score ( $r=.76$ ), Picture Arrangement ( $r=.83$ ), and Number ( $r=.64$ ). These correlations are all significant beyond the .01 level.

Hypothesis 7 was supported in the prediction that conservation scores would correlate more highly with mental age than chronological age. To test this hypothesis, the significance of the difference

between the two correlations was calculated. A critical rate of 2.09 was obtained, which was significant at the .05 level on the one-tailed test of significance.

Table 2. Analysis of variance and means of pretest scores compared with posttest scores on Piaget Type Test for Conservation.

	Means	F Test Value
Pretest	5.79	
Posttest	12.76	79.98
Degrees of Freedom=1/16	F at .05 level=4.49	F at .01 level=8.53

Table 3. Analysis of variance and means for pretest scores compared to posttest scores on Information subtest.

	Means	F Test Value
Pretest	5.76	
Posttest	6.82	14.56
Degrees of Freedom=1/16	F at .05 level=4.49	F at .01 level=8.53

Table 4. Analysis of variance and means for pretest scores compared to posttest scores on Picture Arrangement subtest.

	Means	F Test Value
Pretest	10.41	
Posttest	13.05	6.62
Degrees of Freedom=1/16	F at .05 level=4.49	F at .01 level=8.53

Table 5. Analysis of variance and means for pretest scores compared to posttest scores on Number Concept Test.

	Means	F Test Value
Pretest	9.64	
Posttest	11.23	6.99
Degrees of Freedom=1/16	F at .05 level=4.49	F at .01 level=8.53

Table 6. Analysis of variance and means for pretest scores compared to posttest scores on Conservation Test with Motivational Involvement.

	Means	F Test Value
Pretest	.70	
Posttest	2.30	15.97
Degrees of Freedom=1/16	F at .05 level=4.49	F at .01 level=8.53

Hypotheses 8-12 were supported in predicting significant mean gains in Conservation, Information, Picture Arrangement, and Number test scores, and Conservation Test with Motivational Involvement. Results of analyses pertaining to these hypotheses are reported in Tables 3-6. Gains on the Piaget Type Test for Conservation ( $F=79.98$ ) and the WISC Information subtest ( $F=14.56$ ) were significant beyond the .01 level. Mean gains of the WISC Picture Arrangement subtest ( $F=6.62$ ) and the Number Concept Test ( $F=6.99$ ) were significant beyond the .05 level. The Mean gain on the Conservation Test with Emotional Involvement ( $F=15.97$ ) was significant beyond the .01 level.

Table 7. Product-moment correlations of Conservation Test with Emotional Involvement posttest scores with various gains.

	Gains on WISC Information	Gains on WISC Pict. Arr.	Gains on Number
Conservation Test with Emotional Involvement (df=16)	.260	.355	.078

None of the above correlations attain the .05 level of significance.

Hypotheses 13-15 were not supported. These predicted that posttest scores on the Conservation Test with Motivational Involvement would discriminate between subjects who had posttest increases on Information, Picture Arrangement, and Number Concept scores and those who did not. Correlations were obtained between posttest scores on the Conservation Test and gains in the other three, and reported in Table 7. Correlations of Conservation with Information was .26, with Picture Arrangement .35, and with Number .078. None of these attained the .05 level of significance.

## DISCUSSION

### Evaluation of Findings

A small sample of a relatively narrow range of intelligence was chosen for the experimental group in an attempt to evaluate the effects of a concentrated treatment over a short time. The findings were not entirely agreeable with existing reports (Smedslund, 1962; Piaget, 1964). Because of the small group and this disagreement, the findings are thus considered tentative, but also worthy of further investigation.

Relationships between conservation<sup>1</sup> and I.Q. have been previously reported by Elkind (1961a), Dodwell (1961, 1962), Feigenbaum (1963), and Overholt (1965). Elkind and Dodwell obtained correlations of .43 and .39 respectively; Feigenbaum found significant relations using chi-square; and Overholt compared mean I.Q.'s of conservers and non-conservers. In the present study, also, pretest conservation scores correlated highly with intelligence measures ( $r=.72$ ). This correlation is relatively high, and to what factors this can be attributed will have to await further research. However, it does seem well established that standard intelligence measures and conservation measures have some variance in common. Since I.Q. is a composite of several factors, this relationship could certainly be expected.

Elkind (1961) also found significant correlations between several WISC subtest scores and scores on Piagetian tests for the concept of

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<sup>1</sup>Conservation refers also to measures of Correspondence included in the test Appendix A.



quantity. His highest correlations were with the Information and Pictures Arrangement subtests. Because of this, these particular subtests were chosen for measures of transfer in the present study. Conservation scores correlated .76 with Information and .83 with Picture Arrangement as compared to .47 and .55 obtained by Elkind with a larger group. These are higher than the correlation with I.Q. Since I.Q. is a composite of factors, it might be speculated that these subtests and conservation may tap some common factor. This strong relationship supports the use of the Information and Picture Arrangement subtests as measures of the transfer of learned conservation.

The relation between conservation and age is basic to Piagetian theory and has been well covered in earlier research. Of interest in the findings of the present study was the very high correlation of conservation scores with mental age ( $r=.91$ ). This correlation was significantly higher than that between conservation scores and chronological age ( $r=.62$ ). This finding is consistent with a report by Hood (1962) who noted a stronger relation between conservation and mental age than between conservation and chronological age. Woodward (1959, 1960) has also reported the slower progress of retardates through Piagetian stages of development; and Lovell, Healey and Roland (1962) obtained higher chronological age-conservation correlations for normal than for retarded children. Since mental age is an estimate of the maturity level of the child, these findings are supportive of Piaget's general developmental theory.

Conservation scores correlated significantly with Number Concept scores ( $r=.64$ ). However, since conservation and correspondence are a part of number conception, this correlation was expected to be higher

than those discussed above. That this was not the case may be due to an inadequacy in the domain of number conception sampled by the Number Concept Test. Dodwell (1961) and Overholt (1965) both found significant relationships between level of conservation attainment and number or arithmetic achievement.

In the present study the correlation of I.Q. scores to Number Concept scores was .56 as compared to .64 between conservation and number. Partialling out I.Q., the correlation between Conservation and Number Concept scores was .40. When conservation was partialled out, the correlation between I.Q. and number was .19.<sup>†</sup> There is apparently more common variance between Conservation and the Number Measure than between I.Q. and Number. This suggests a possible usefulness for measures of conservation in diagnosis of students having difficulties in arithmetic and related areas.

➤ In teaching conservation and correspondence to children, the major objective was to measure for transfer.<sup>†</sup> Piaget (1964) has questioned the permanency and the degree of generalization of these concepts when learned by conditioning.<sup>‡</sup> In an effort to get at the second question of generalization, two basic approaches were taken. One, tasks in the learning situations were different from those used in the conservation pretest and posttest. Hence, the posttest was considered to measure some degree of transfer of what was learned in the learning sessions. Two, the WISC subtests of Information and Picture Arrangement and the Number Concept Test all have common variance with the conservation test. However, this relationship is much less direct than that of the learning tasks to the conservation test tasks. These measures were used, then, to measure a more generalized transfer. Wolensky (1962),

Gilmore (1964), Stendler (1965) and Overholt (1965) are previous writers who have suggested the need for teaching Piagetian concepts and measuring the effects on other related areas of performance.

The subjects were presented with 12 tasks involving conservation and correspondence (Appendix A). Correct answers were allotted 1 point, and there was a possible 16 points on the measure. The 17 pretest scores ranged from 2 to 12 with a mean of 5.79. Those subjects scoring at the lower end of the range obtained a few points due to training in provoked correspondence. Seven of the subjects fell into this category and were judged to be at stage 1 which is actually the non-conserving stage. The remaining ten were judged to be in stage 2 since they conserved in some tasks and not in others.

After the learning sessions, all subjects showed gains on the conservation posttest. The range of scores on the posttest was from 5 to 16 with a mean of 12.76. Testing for significance of mean differences (pretest vs posttest means), an F ratio of 79.98 was obtained where 8.53 was required for the .01 level of significance. From these findings it was concluded that the attainment of conservation can be accelerated by learning. This conclusion is in line with the findings of Smedslund (1961), Bruner (1966), Senstroem (1966) and Churchill (Dodwell, 1960).

However, Smedslund (1961) found conservation learned through reinforcement was easy to extinguish and accredited this to the manner in which the conservation was attained. Since only one basic learning task was used in Smedslund's study, it is possible that extinction in this case was due to inadequate learning rather than to the manner in which conservation was attained. Concerning Smedslund's work, Piaget

(1964) noted that transitivity could not be taught in the same manner as weight conservation, and reported that this illustrates a learning of facts but not of logical structure.

→ The learning tasks in the present study were different from the testing tasks. Thus, there was some degree of transfer if the gains on posttest were due to learning. Some of the tasks did involve the principle of transitivity, but it is not maintained that the logical structure was learned. Certain external clues due to familiarity from a variety of tasks could have led the subjects to the correct answers. More adequate questioning as to "why" the subjects conserved might have added enlightenment to this question.

To test whether conservation attained through learning would transfer to areas of performance not directly involved in conservation, the Information and Picture Arrangement subtests of the WISC and a Number Concept Test were used. Gains on the Information test were significant beyond the .01 level ( $F=14.56$ ). For the Picture Arrangement and Number Concept tests, gains were significant beyond the .05 level ( $F$ 's=6.62 and 6.99 respectively).

The question as to what caused the gains in Conservation, Information Picture Arrangement and Number Concept tests is not answered by the data. It is possible that conservation can be adequately learned and that this learning transfers to affect other areas of performance. But, it is also possible that the children learned to improve their mode of attack on the problems presented them rather than changing their mental process. It is also possible that improved concentration due to familiarity with similar problems and the conditioning techniques used in the study improved their scores. Further

research with more refined design and techniques will be needed to answer which, if any, of these alternatives might be the case.

Practice effect on posttest scores is possible, but considered negligible. WISC subtests have been found relatively unaffected by practice. Almy et al. (1967) found that conservation tests separated at 1 to 2 week intervals were not affected by practice. An alternate form of the Number Concept Test was used, and similar results were obtained as with the other measures where pretest and posttest were the same.

The permanency of the above findings has not been tested. Piaget (1964) points to this as an important question to consider when evaluating the results of teaching such basic concepts as conservation. This, then, is another area for future research.

A third aspect of the present study was the attempt to measure whether or not the conservation learned by the subjects was truly internalized. For this purpose, the Conservation Test with Motivational Involvement was used (Appendix C). In this test, the subjects actually were allowed to keep to quantities which they chose. For example, they had learned (or been conditioned) to say a longer row of candies was equal in number to a shorter row regardless of density. The rationale was that if they did not believe what they said, they would choose the longer row of candies when forced with a choice which mattered to them.

First, mean gains on the Conservation Test with Motivational Involvement ( $F=15.97$ ) were significant beyond the .01 level. This indicates the subjects were relying on conservation in a situation where their decision was of importance to them. From this finding,

it is inferred that there was, at least to some degree, an internalization of the conservation concept.

Secondly, it was hypothesized that posttest scores on this test would be positively correlated with gains on the Information, Picture Arrangement, and Number tests. None of the predicted correlations attained the .05 level of significance (Table 2), although two of them approached this level. The limited score range (0-3) on this conservation measure may have been a limiting factor in obtaining more significant correlations.

#### Summary of Evaluation

The findings of this study indicate strong relationships between conservation, intelligence and understanding of number; all of which are generally supported in the literature. It seems the attainment of conservation can be accelerated by learning, although the permanency of the process achieved in this manner was not established by this study. Very tentatively, the data of this study supports the hypothesis that teaching children conservation can improve performance in other areas. Other possible causes for the gains found in the present study are learning to be cautious, generalizing external cues, better concentration due to reinforcement, and practice effect. Finally, the attempt to measure internalization of the Piagetian concepts was partially successful, but there were not significant, positive correlations between posttest scores on the measure used for this purpose and gains on measures of transfer.

## Observations on Methods and Procedures

### Interactions with subjects

Some observations concerning question presentation, response sets, and the operant technique used in the study are deemed significant to studies of this type.

Wording of questions is an important variable in assessing levels of conservation. For example, when a child is asked "are the quantities still the same," he may say yes either because of an acquiescent tendency or because he is conserving. On the other hand, if he is asked, "which is more," he may feel forced to make a choice even if he believes the two quantities are equal. If asked, "is there more here or here, or are they the same," he may repeat the last statement he hears without really believing what he says (or conserving). Before scoring a child on a particular task, it was found important to use various combinations of these types of questions and to avoid concluding on the child's first response. With this technique, it usually became clearly evident what the child believed.

On the number test, it was found that to ask, "which would you rather have 6 pennies or 8 pennies," was much different than asking, "which would you rather have 8 pennies or 6 pennies." The first question is inadequate because a child who does not know the cardinal value of numbers would have a strong tendency to say 8 because it was the last number he heard. He could then be scored correct without knowing the answer. The second question avoids this problem. The tendency of "when in doubt, repeat the last thing you hear" was very strong in the subjects of the present study. Hood (1962) has also noted this tendency in children. Knowledge of this response set could

be useful to teachers in evaluating understanding of number in children. Without knowing of this, teachers could get erroneously high estimates of children's understanding of numbers.

To maintain attention to the tasks and provide motivation for achieving success, a system of immediate and delayed reinforcement was used. The child was given a penny immediately upon correct responses to questions in the learning sessions. At the end of each session, he could buy treats with his accumulated pennies.

The effects of this technique were to produce high interest. Early in the first learning session the children, by their behavior, indicated they had learned the reinforcers were contingent upon how well they attended to the learning tasks. There was a minimum of confusion and evidence of good concentration after the first few minutes of the first learning sessions. The few relapses in behavior which occurred were quickly controlled by reminding the child of how he earned his pennies. In addition, the subjects were very anxious to participate in subsequent sessions.

#### Discussion of tests used

→ Concerning the conservation and correspondence measures used in the study, it is believed that important improvements can be made by increasing the maximum possible scores.

The Piaget Type Test for Conservation had a maximum of 16. One subject who scored 12 on pretest scored 16 on the posttest with a gain of 4. Another subject scored 6.5 on pretest and 14.5 on posttest, obtaining a gain of 8. For the first subject, there is a strong possibility that his maximum score on posttest would have exceeded 16 if possible.



Without adding items to the test, an improvement would be made by adding "why" questions following conserving responses. During the present study, many "why" questions were asked; but no accommodation for these answers was built into the scoring system of the tests. Allowing from 0 to 3 points on each question rather than 0 to 1 would probably adequately increase the upper limits of the test score.

† The same argument holds for the Conservation Test with Motivational Involvement. The usefulness of this test in correlations was decidedly limited by the maximum score of 3. Increasing the maximum score might have been an important factor in the correlations in the present study.

#### Recommendations for Further Research

The present study was exploratory. With the small, relatively homogenous sample of this study, the findings were encouraging for further research.

† A replication study with improved scoring ranges on conservation and more varied, reliable, and valid measures of transfer seems warranted.

† Similar research with a larger, more representative sample and a control group is recommended. This would make possible the consideration of the permanence of learning as well as the practice effect.

† To test the hypothesis that conservation tasks are both diagnostic and corrective tools for children having problems in arithmetic seems important. A sample of children not succeeding in grade 1 or 2 arithmetic could be compared to a successful sample on conservation levels. Those found to be non-conservers could be taught the concept and tested for effects in arithmetic performance.

The present study was not refined enough to test specifically for logical structures such as transitivity. More precise measurement of exactly what precise concepts the child has or has not learned is needed to get at Piaget's (1964) question of whether logical operations such as transitivity can be taught.

→ There is a possibility that the teaching of concepts such as conservation is more important to mentally retarded than to normal children. They do not seem to benefit from experience as do normal children, or in other words, they have less incidental learning (Robinson and Robinson, 1965). It is thus believed that experimentation with this approach with the mentally retarded holds promise.

## SUMMARY AND CONCLUSIONS

### Background

The general problem of the study was to investigate the Piagetian concepts of conservation and correspondence as they related to learning and also to other areas of performance with the mentally retarded child.

A review of literature showed that Piaget's general views on intellectual development were holding up in experimental investigations. There were, however, disagreements on details.

Research indicated a relationship of the level of conservation attainment to both intelligence and number conception. Some studies reported success in teaching conservation to non-conservers. Other writers suggested teaching conservation and similar concepts as a method for improving performance in other areas.

### Procedure

Seventeen educable retarded subjects were administered pretests on Conservation, Information and Picture Arrangement sub-tests of WISC, and a Number Concept Test.

Following the pretests, the subjects were taught conservation (and correspondence) in small groups using variations on Piaget's experiments as learning devices. The tasks used for learning sessions were different from those used in testing.

After five 50 minute learning sessions, posttests were administered using the same instrument as used for pretests with the exception of Number Concept Test where a parallel form was used.

### Hypotheses

(1) There will be a positive correlation between conservation pretest scores and intelligence test scores.

(2-6) These were the same as 1 for (a) WISC Information (b) WISC Picture Arrangement (c) chronological age (d) mental age (e) number concept.

(7) The scores on the conservation pretest will correlate significantly higher with mental age than with chronological age.

(8) For the conservation test, the posttest scores will be significantly higher than the pretest scores.

(9-12) These were the same as 8 for (a) Information (b) Picture Arrangement (c) Number Concept test scores, (d) Conservation Test with Motivational Involvement.

(13) Posttest scores on the Conservation Test with Motivational Involvement will discriminate between subjects whose posttest scores do or do not increase over pretest scores on the Information sub-test.

(14-15) These were the same as 12 for (a) Picture Arrangement (b) Number Concept test scores.

### Results

Hypotheses 1-6 were supported by correlations ranging from .640 to .915, all significant beyond the .01 level.

Hypothesis 7 was supported at the .05 level on the one tailed test with a critical ratio of 2.08 comparing correlation coefficients.

Hypotheses 8 and 9 were supported beyond the .01 level using analysis of variance with F ratios of 79.98 and 14.56 respectively.

Hypotheses 10 and 11 were supported beyond the .05 level using analysis of variance with F ratios of 6.62 and 6.99 respectively.

Hypothesis 12 was supported beyond the .01 level with an F ratio of 15.97.

Hypotheses 13-15 were not supported. Correlations between scores on the Conservation Test with Motivational Involvement and gains on the Information, Picture Arrangement, and Number Concept tests did not attain the .05 level of significance.

### Conclusions

The conclusions are:

- (1) Measures of intelligence, number and conservation are positively related.
- (2) The relation of conservation attainment to mental age is stronger than the relation of conservation attainment to chronological age.
- (3) Tentatively, it seems conservation and correspondence attainment can be accelerated by learning.
- (4) Significant gains on various posttest scores suggest the possibility that learning conservation affected performance in other areas. However, improved concentration and/or mode of attack are not excluded as underlying factors in these gains.
- (5) The findings indicate internalization of the conservation concepts. However, posttest scores on the Conservation Test with Motivational Involvement did not correlate significantly with gains on other measures.

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## APPENDIXES

## Appendix A

### Piaget Type Test for Conservation

There was one point allowed for each correct conclusion. Four variations were presented for each concept to be tested, making possible 16 points on the complete test. Following are the tests for the 4 concepts being considered in the study.

#### I. Conservation of Continuous Quantities

(a) 2 cylinders, A1 and A2, of equal dimensions and containing the same amount of liquid were presented to the subject. The contents of A2 were poured into 2 smaller containers, B1 and B2. The child was then asked if the liquid in B1 and B2, from A2, was still equal to the liquid in A1. This was repeated using B1 and B2 as starting points.

(b) Same as (a) only the contents of A2 were poured into one other cylinder of different shape. Two variations of this were used.

#### II. Conservation of Discontinuous Quantities

(a) Same as I (a) but beans were used instead of liquid.

(b) Same as I (b) but beans were used and the child counted.

#### III. Provoked Correspondence and Conservation of Equivalence

(a) A certain number of milk bottles were placed on the table. The child was asked to remove an equal number of glasses from a tray. When the child had done this, the glasses were bunched together, and he was asked if they were still equal in number to the milk bottles. Two variations of this were used.

(b) Same as (a) but using flowers and vases.

#### IV. Spontaneous Correspondence

(a) A random arrangement of beans was placed on the table. The child was asked to place an equal number of beans beside the original arrangement. Two variations were used.

(b) Same as (a) but the beans were arranged first in rows, then in a circle.

## Appendix B

### Conservation with Motivational Involvement

I. Used item I (b) but with fruit juice as the liquid. Extra juice was added to the shorter container, then the child was asked which he wanted to drink.

II. Used item II (b) but with M & M candies. An extra candy was put in the shorter container, then the child was asked which he would rather eat.

III. Used item IV (b) but with pennies. Extra pennies were added to the more dense row, and the child was given his choice.

### Appendix C

#### Variations on Piaget Tests for Learning Experiences

##### I. Conservation of Continuous Quantities

1. Equal cubes of clay, one was molded into different shape.
2. Child was presented with a container A with liquid in it. He was asked to pour the same amount in container of different shape.
3. Rubber bands of equal length, one was stretched.
4. Sheets of paper of equal dimensions, one was folded.
5. Strings of equal length, one was arranged in different shape.

##### II. Conservation of Discontinuous Quantities

1. Two stacks of checkers, one was divided into shorter stacks.
2. Same as I (2) but with beans,
3. Four pieces of string of equal length arranged in pairs to form lines of equal length, one pair was rearranged to form parallel lines.
4. Two sets of 4 cardboard squares of equal dimensions each arranged end to end. One set was rearranged into a large square.

##### III. Provoked Correspondence

1. Cardboard dolls and hats.
2. Toothpaste tubes and outer boxes.
3. Pop bottles and caps.
4. Egg cups and eggs.
5. One-one exchange, one coin for one item.

##### IV. Spontaneous Correspondence

1. Blocks.
2. Checkers,
3. Coins.
4. Small cardboard squares.
5. Short pieces of string.

For each of the above, same techniques as in Tests.

### Appendix D

#### Number Concept Test\*

1. Would you rather have 28 pennies or 25 pennies?
2. Would you rather have 49 pennies or 44 pennies?

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\*Parallel form was the same, except numbers were changed

3. Which is more 139 cows or 129 cows?
4. If you had 6 candies and I gave you 5 more, how many would you have?
5. If you had 9 pennies and I gave you 8 more, how many would you have?
6. If you had 13 candies and ate 6 of them, how many would be left?
7. If you had 18 pennies and spent 5 of them, how many would be left?
8. Here are 10 beans. Give me half of them and you keep half.
9. Here are 12 beans. Give me half of them and you keep half.
10. If one pencil cost 5 cents, how much would 2 pencils cost?
11. If there were 3 boxes with 4 marbles in each box, how many marbles would there be altogether?
12. If 2 pencils cost 10 cents, how much does one pencil cost?
13. If there are 12 apples for 3 persons, how many apples will each person get?
14. A family has 4 boys and 3 girls. Are there more boys or girls?
15. A farmer has 18 cows and 16 sheep. Does he have more cows or sheep?
16. A quarter is 25 pennies. 4 nickles are 20 pennies. Would you rather have 1 quarter or 4 nickles?
17. My house is 6 blocks from the school. How many blocks is half way to my house.
18. One cat has 10 whiskers, another cat has 8 whiskers. Which has fewer whiskers.
19. An elephant's tail is 35 inches long, his trunk is 38 inches long. Which is shorter?
20. 3 dozen is 36. Would you rather have 3 dozen candies or 34.

## VITA

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Candidate for the Degree of

Doctor of Philosophy

Dissertation: Variations on Piaget's Pre-Number Development Tests Used  
as Learning Experiences

### Biographical Information:

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